

Research Paper

An Economic Analysis of Poplar Cultivation in Punjab

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ABSTRACT

The present study analyzed the economic viability of poplar based agro-forestry system in Punjab. Primary data were collected from a sample of 60 adopters and 32 non-adopters of agro-forestry from 4 clusters of villages from Ludhiana and Ropar districts of Punjab state pertaining to year 2013-14. Two types of agro-forestry systems AFS-I (wheat + kharif fodder during 1st four years of poplar cultivation) and AFS-II (sugarcane for first two years and wheat during 3-4 years) were identified. The establishment cost was estimated at ₹ 7,871 per acre for an average farmer. The operational cost was worked out at ₹ 3,724 during 1-4 years and ₹ 2,919 during 5-6 years of plantation in AFS-I on per acre basis. The per acre operational cost in AFS-II was estimated at ₹ 1,904 during 1-2 years, ₹ 5,071 during 3-4 years and ₹ 3,630 during 5-6 years of poplar plantation. The net returns were ₹ 2,02,463, ₹ 2,05,283 and ₹ 2,29,720 in AFS-I and ₹ 2,19,015, ₹ 1,78,832 and ₹ 2,00,639 in AFS-II at 4th, 5th and 6th years of harvesting on per acre basis. The benefit-cost ratio and net present value were the highest at 5th year of harvesting in case of AFS-I and AFS-II. The analysis of benefit-cost ratio and net present value showed that the investment in poplar cultivation is considered to be economically viable during the study year.

Highlights

- ① The annual returns from poplar in both the systems i.e. AFS-I and AFS-II were found to be higher than the wheat and paddy crop rotation, if the harvesting of poplar is done at the age of 4th year.
- ② The poplar plantation was more beneficial than wheat and paddy crop rotation during the study year at the estimated costs and price of poplar as well as intercrops.
- ③ It is concluded from the analyze that the undiscounted returns increased with the increase in the age of poplar but using discounting criteria it is indicated that the returns are highest at the age of 4th year if cost of capital is 15 per cent and above.

Keywords: Economics of poplar cultivation, Benefit-cost ratio, Net present value

Punjab is an agricultural state. Wheat and paddy crops occupy more than 80 per cent cropped area of the state, but only 6.5 per cent area is under forests (Anonymous, 2017). The excessive use of agrochemicals in rice and wheat rotation has depleted and deteriorated soil health and water resources in the state (Sidhu, 1998). Diversification in rice-wheat crop rotation has strongly been advocated in irrigated agro-ecosystem (Aulakh, 2005 a&b; Johl, 2005). The declining diversity has severe effect in terms of overuse of water resources, soil nutrients and ecological problems such as air, water and soil pollution. The stagnation in the state agriculture requires corrective policy measures to increase the productivity on farms (Singh *et al.* 2000). Breaking away from crops like wheat

and paddy, Poplar seems to be good alternative, because of its fast growth, straight growing stem, short rotation, quality wood production and profitability, has been extensively planted in north-western states of India-Haryana, Punjab and Uttar Pradesh (Chauhan and Mangat, 2006). According to World Bank in developing countries, about 1.2 billion people rely on agro-forestry farming systems that help to sustain agricultural productivity and generate income (World Bank, 2002). Poplar (*Populus deltoides*) is a very prominent taxonomical

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group of tree species in plantation forestry in India. Owing to very little risks and high profits in poplar cultivation, large farmers and absentee land-lords prefer to put their lands under poplar-based agro-forestry rather than other agriculture/agro-forestry options. The farm-industry linkages have also helped the systems to be more sustainable than the traditional cropping systems (Saxena, 2000 and Kareemulla *et al.* 2005). Fazli (1990) and Khan and Betters (1990) stated that all the agro-forestry systems were more beneficial as compared to the most common cropping pattern (paddy wheat cropping rotation). Poplar wood can be used for paper, plywood, match sticks, packing boxes, playing items, furniture industry, etc. Marketing of poplar wood is comfortable and wood can be sold in Yamunanagar-Jagdhari and local markets in Punjab and Uttar Pradesh. Intercropping is recommended as it provides agricultural returns on the one hand and results in increased growth rate of poplar on the other due to frequent irrigation and hoeing operations of agricultural crops (Shah, 1988 and Chauhan *et al.* 2015). Present study tends to analyse the economics of poplar based agro-forestry vis-à-vis wheat-paddy cultivation in Punjab.

MATERIALS AND METHODS

This study was undertaken in the Punjab state. Ludhiana and Ropar districts had the more area under poplar cultivation as compared to the other districts of the state. Therefore these two districts were selected for the study. At the second stage of sampling, two cluster of villages each comprising of four/five villages were selected from the selected districts. In the third stage, fifteen adopters and eight non-adopters of poplar based agro-forestry were selected from each selected clusters. For comparison purpose, a sample of 32 non-adopter farmers were selected, thus a total sample of 92 farmers (60 adopters and 32 non-adopters) covering twenty villages, four clusters and two districts of Punjab state was finally selected for the study. The data regarding establishment cost, which includes cost of nursery, plantation cost, operational cost and socio-economic parameters were collected for the year 2013-14. The information relating to cost of cultivation, gross returns, returns over variable cost from wheat and paddy has been estimated for the sample non-adopter farmers on per acre basis.

Analytical Tools

To analyze the results, simple tabular analysis was used. Budgeting technique was used to work out the economics of poplar along with other selected agricultural crops grown i.e., wheat, sugarcane and *kharif* fodder. In order to further examine the plantations along with crops in terms of productivity of capital, the concept of discounting was used. The costs and benefits were discounted at the rate of 10, 12 and 15 per cent. Cost and income from intercrop as well as poplar plantation was calculated.

(i) Net Present Value (NPV)

It is the present value of net benefits that the project will generate over and above that would be available, if the amount proposed to be invested in the project is invested at the current rate of interest elsewhere. In NPV, each item of the costs and benefits is discounted to its present value over the life of the project and then summed up to find out the net value. The formulae expression of NPV is given as under:

$$NPV = \sum_{i=1}^n \frac{Bi - Ci}{(1+r)^i}$$

(ii) Benefit-Cost Ratio (BCR)

It is the ratio of sum of discounted benefits to the sum of discounted costs. Using the same notations as NPV, BCR can be expressed as follows:

$$BCR = \frac{\sum_{i=1}^n \frac{Bi}{(1+r)^i}}{\sum_{i=1}^n \frac{Ci}{(1+r)^i}}$$

(iii) Annuity Value (AV)

It was the equalized yearly value over the life of the project which discounted at a given rate, had generate the NPV equal to that generated by the project at the same discount rate. Again, using the same notations as earlier, annuity value can be expressed as:

$$AV = \frac{NPV}{\sum_{i=1}^n \frac{1}{(1+r)^i}}$$

RESULTS AND DISCUSSION

Cost Structure for Raising the Plantation

Cost components for raising the plantation have been divided into two main categories as establishment and operational costs. The establishment cost includes the cost of planting material, transportation, transplanting, plant protection chemicals, fertilizer cost, irrigation cost and cost of labour used in all operations. The establishment cost was assumed to be fixed cost for the remaining life of the plantation. The operational cost is the cost which incurred during the period after plantation of tree (establishment cost) till trees are harvested. It included the costs of manure and fertilizers, irrigation, plant protection chemicals, pruning etc. The operational cost varied according to the agro forestry system adopted. The operational cost of intercrops includes cost of seed, fertilizer, irrigation and harvesting. Labour cost was included in each operation.

Establishment cost of poplar cultivation

Establishment cost was incurred at the start of the plantation considered to be zero year i.e. just in the beginning of year 1. The total cost of establishment of poplar was ₹ 7,871 per acre (Table 1).

Table 1: Establishment cost of poplar cultivation
(Average No. of plants 267/acre)

Particulars	Cost/acre (₹)	Per cent
Cost of nursery	4967	63.10
Cost of planting	1260	16.01
Fertilizers	387	4.92
Transportation cost	748	9.50
Plant protection chemicals	509	6.47
Total cost	7871	100.00

The highest cost item of expenditure was incurred on cost of nursery of plants which was worked out to be ₹ 4,967 per acre, constituting 63.10 per cent to total establishment cost, followed by cost of planting operation which was ₹ 1,260 per acre, contributing 16.01 per cent of total establishment cost. Cost of transportation (9.50%), cost of plant protection chemicals (6.47%) and cost of fertilizers (4.92%) were other component of establishment cost.

Operational cost of poplar cultivation for Agro-forestry system-I

Operational cost is the cost which incurred during the period after establishment of forestry till trees are harvested. The operational cost varied according to the agro forestry system adopted by the farmers and hence was estimated separately for the following two most important systems followed by the sample farmers.

- *Agro forestry system I (AFS-I):* Poplar with wheat in *rabi* season followed by *kharif* fodder as intercrop.
- *Agro forestry system II (AFS-II):* Poplar with sugarcane for first two years and then wheat for the next two years as intercrop.

It was observed during the survey that the farmers sold the poplar plants from the age of 4 years of poplar and maximum to the age of 6 years. The annual operational cost for the first four years and from five to six years is given separately both for agro-forestry system-I and II.

Poplar with wheat in *rabi* season followed by *kharif* fodder as intercrop is referred as agro-forestry system-I. The operational cost of poplar cultivation for agro-forestry system-I are presented in Table 2. It was observed that ₹ 3,724 were spent on poplar cultivation in 1-4 years and ₹ 2,919 were incurred in remaining two years of plantation on per acre basis. Pruning constituted 33.43 per cent of costs, followed by 23.36 per cent on manure and fertilizer, 18.21 per cent on plant protection chemicals, 17.40 per cent on irrigations and 7.60 per cent on miscellaneous costs during 1-4 years. It was estimated that during 5-6 years of poplar age highest proportion (51.87%) was incurred on manure and fertilizer followed by (34.53%) on irrigations. Though electricity is available free of cost to farmers in Punjab, but it was observed that at the time of harvesting of wheat in the month of April no electricity supply is available. Farmers used diesel engine to irrigate poplars.

Operational cost of poplar cultivation for Agro-forestry system-II

Poplar with sugarcane for first two years and then wheat for the next two years as intercrop is referred as agro-forestry system-II. The operational cost was found to be ₹ 1,904 per acre per annum during 1-2 years, ₹ 5,071 during 3-4 years and ₹ 3,630 per

Table 2: Operational cost of poplar cultivation in Punjab for agro-forestry system-I

Particulars	AFS-I			
	Age (Years) During 1-4 years	Per cent	Age (Years) During 5-6 years	Per cent
Manure and fertilizers	870	23.36	1514	51.87
Irrigations	648	17.40	1008	34.53
Pruning	1245	33.43	—	—
Plant protection chemicals	678	18.21	226	7.74
*Misc.	283	7.60	171	5.86
Total cost	3724	100.00	2919	100.00

*Miscellaneous cost includes cost of hoeing and weeding, cultivation in between the rows to get rid of unwanted vegetation when no crop is raised.

Table 3: Operational cost of poplar cultivation in Punjab for Agro-forestry system-II

Particulars	AFS-II			
	Age (Years)	During 1-2 years	During 3-4 years	During 5-6 years
Manure and fertilizer	—	1797 (35.44)	1779 (49.01)	—
Irrigations	—	1082 (21.34)	1484 (40.88)	—
Pruning	967 (50.79)	1269 (25.02)	—	—
Plant protection chemicals	680 (35.71)	649 (12.80)	225 (6.20)	—
Misc.	257 (13.50)	274 (5.40)	142 (3.91)	—
Total cost	1904 (100.00)	5071 (100.00)	3630 (100.00)	—

Figures within the parentheses are percentages to their respective total.

Table 4: Cost and returns from poplar cultivation (undiscounted) according to age of harvesting for AFS-I and AFS-II

Particulars	AFS-I			AFS-II				
	Harvesting Age (Years)	4	5	6	Harvesting Age (Years)	4	5	6
Gross Returns	176483	205283	229720	176483	205283	229720	—	—
Establishment cost	7871	7871	7871	7871	7871	7871	7871	7871
Operational cost	14896	17815	20734	13950	17580	21210	—	—
Total cost	22767	25686	28605	21821	25451	29081	—	—
Net Returns	153716	179597	201115	154662	179832	200639	—	—

acre per annum were incurred during 5-6 years of plantation in agro-forestry system-II. Pruning constituted 50.79 per cent of costs, followed by 35.71 per cent on plant protection chemicals and 13.50 per cent on miscellaneous costs in the first two years and during the 3-4 years of plantation, it was estimated that highest proportion 35.44 per cent was incurred on manure and fertilizer followed by 25.02 per cent on pruning, 21.34 per cent on irrigations, 12.80 per cent and 5.40 per cent on plant protection chemicals and miscellaneous costs respectively. During the 5-6 years of plantation crop, it was observed that highest proportion (49.01%)

was incurred on manure and fertilizer followed by (40.88%) on irrigations (Table 3).

Cost and returns from poplar cultivation (undiscounted) in AFS-I and AFS-II

The total annual cost of poplar cultivation does not vary much with the age of plants. Table 4 showed the per acre basis undiscounted returns from poplar plantation for agro-forestry system-I. The gross returns per acre came to be ₹ 1,76,483 if the plants were harvested at the age of 4th year whereas the farmers who harvested the plants at the age of 5th and 6th years then they received ₹ 2,05,283 and

₹ 2,29,720 returns respectively. The total cost came to be ₹ 22,767 per acre during 4th year which increased to ₹ 28,605 per acre during 6th year. The net returns worked out ₹ 1,53,716 during 4th year to ₹ 2,01,115 during 6th year of poplar plantation. In case of Agro-forestry system-II, the total cost of poplar cultivation was estimated at ₹ 21,821, ₹ 25,451 and ₹ 29,081 during 4th, 5th and 6th year respectively with ₹ 1,76,483, ₹ 2,05,283 and ₹ 2,29,720 of gross returns. The net returns in agro-forestry-II was estimated to be ₹ 1,54,662 in the 4th year, ₹ 1,79,832 in the 5th year and ₹ 2,00,639 in the 6th year of harvesting age of poplar.

Year-wise cost and returns from intercropping of poplar cultivation for AFS-I and AFS-II

The streams of costs and returns from intercropping of wheat, sugarcane and kharif fodder is shown in Table 5. In agro-forestry system-I, the costs and returns were inversely related to age of the plantation with the increase in age of the plantation and the costs and returns from intercrops declining. In Agro-forestry system-II, the cost of intercropping of sugarcane amounted to ₹ 45,858 in the first year and decreased to ₹ 39,790 in the second year. The gross returns were declined at ₹ 71,150 and ₹ 55,111 per acre of sugarcane cultivation. The net returns worked out ₹ 25,292 during 1st year and ₹ 15,321 in the 2nd year of sugarcane cultivation in AFS-II. The

cost of wheat cultivation was estimated at ₹ 12,228 and ₹ 11,831 during 3rd and 4th year respectively. The gross returns from wheat cultivation decreased during 3rd year and the 4th year due to increased canopy of poplar plantation and were ₹ 25,261 and ₹ 22,538. The net returns from intercropping came to be ₹ 13,033 and ₹ 10,707 per acre in the 3rd and 4th year of poplar cultivation respectively. The analysis in agro-forestry system-II highlighted that the cost and returns from intercropping were inversely related to age of the poplar plantation. Same trends were also recorded by Kumar (2005).

Cost structure of wheat-paddy cultivation

Wheat and paddy are the main crops cultivated during *rabi* and *kharif* season respectively and cover more than 80 per cent of cropped area in the Punjab state. Cost of cultivation of wheat-paddy crop rotation has been worked for the non-adopters of agro-forestry system to compare the returns with poplar cultivation. The information relating to cost of cultivation, gross returns, returns over variable cost from wheat and paddy has been estimated for the sample non-adopter farmers on per acre basis were summarized in Table 6. The examination of Table 6 shows that the variable cost on production of wheat came to be ₹ 11,641 per acre. Out of this, ₹ 4,964 were incurred on machine labour, ₹ 1,521 on fertilizer and FYM and ₹ 1,141 on seed. The human

Table 5: Year-wise cost and returns from intercropping for AFS-I and AFS-II

Particulars	AFS-I				AFS-II			
	Age of Poplar (Years)				Age of Poplar (Years)			
	1	2	3	4	1	2	3	4
Cost incurred	20056	19188	18869	17715	45858	39790	12228	11831
Gross returns	34239	32231	28880	24225	71150	55111	25261	22538
Net returns	19183	13043	10011	6510	25292	15321	13033	10707

Table 6: Cost of cultivation of wheat-paddy in Punjab

Particulars	Cost of cultivation of wheat-paddy (₹/acre)	
	Wheat	Paddy
Seed	1141	613
Human labour	3224	5941
Machine labour	4964	3972
Fertilizer and FYM	1521	1532
Irrigation charges	285	2550
Insecticides	507	1275
Total cost	11641	15883

labour constituted ₹ 3,224; insecticides cost ₹ 507 by an average farmer. The lowest cost was estimated for irrigation ₹ 285. Therefore, machine and human labour emerged as the higher cost component and irrigation the lowest cost component on wheat production. The cost of paddy cultivation estimated at ₹ 15,883 per acre. Out of this, ₹ 5,941 were incurred on human labour, ₹ 3,972 on machine labour, ₹ 2,550 on irrigation, ₹ 1,532 on fertilizer & FYM and ₹ 1,275 on insecticides. The lowest amount ₹ 613 was incurred on seed. In the case of paddy cultivation the highest cost ₹ 5,941 was incurred on human labour, ₹ 3,972 on machine labour, ₹ 2,550 on irrigation, ₹ 1,532 on fertilizer and FYM and ₹ 1,275 on insecticides. Therefore, human labour emerged as the highest cost component and seed the lowest cost component of paddy production (Table 6).

Returns from wheat-paddy cultivation

The returns from wheat-paddy cultivation were presented in Table 7. The gross returns were worked out by multiplying the yield of wheat crop with price of the crop along with the value of by-product. The yield of wheat was estimated at 21.96 quintal per acre. The gross returns from wheat production came to be ₹ 30,744 per acre and the variable cost was estimated at ₹ 11,641 per acre. The returns over variable cost were calculated by deducting variable cost and it is came to be ₹ 19,103 per acre among non-adopter farmers of agro-forestry. Table 4.3.4 indicated that the yield of paddy crop was estimated at 28.56 quintal per acre with price ₹ 1,310 per quintal. The variable cost, gross returns and returns over variable cost were worked out at ₹ 15,883, ₹ 37,414 and ₹ 21,531 per acre respectively. This indicated that returns from paddy cultivation were higher than that from wheat crop.

Table 7: Returns from wheat-paddy cultivation in Punjab

Particulars	Returns from wheat-paddy cultivation (₹/acre)	
	Wheat	Paddy
Gross returns	30744	37414
Variable Cost	11641	15883
Yield (Qtls)	21.96	28.56
Price/Qtls	1400	1310
Returns over variable cost	19103	21531

Comparative economics of poplar vis-à-vis wheat-paddy cultivation Table 8 shows the comparison of returns from poplar and wheat-paddy crop rotation. For the comparison purpose annuity value was estimated for poplar plantation according to age of harvesting using 12 per cent discount rate. The annuity value was worked out by dividing the net present value with the rate of annuity factor. The annuity values worked out at ₹ 43,386, ₹ 37,322 and ₹ 32,319 for AFS-I and ₹ 47,688, ₹ 40,829 and ₹ 35,350 for AFS-II in the 4th, 5th and 6th year of harvesting age. The net returns on per acre basis from wheat-paddy cultivation were estimated at ₹ 40,744 per annum. Therefore, the annual returns from poplar in both the systems i.e. AFS-I and AFS-II were found to be higher than the wheat and paddy crop rotation.

Table 8: Comparative economics of poplar vis-à-vis wheat-paddy cultivation in Punjab

Annuity Values in different Agro-forestry systems at 12 per cent discount rate (₹/acre)	
AFS-I	AFS-II
	4 th year of harvesting
43386	47688
	5 th year of harvesting
37322	40829
	6 th year of harvesting
32319	35350
	Wheat + Paddy rotation
	40744

Financial viability of poplar cultivation under AFS-I and AFS-II

In order to examine the poplar plantation along with crops in terms of productivity of capital over time, the concepts of discounting was used. The discount rate for costs and benefits was considered at 10, 12 and 15 per cent respectively.

Table 9 presented the financial viability of poplar based agro-forestry system revealed that at different rates of discounts taken to be 10, 12 and 15 in block plantation, the increase in benefit-cost ratio was found to be highest during 6th year being 2.75, 2.65 and 2.51 respectively. The net present value at these discount rates turned out to be ₹ 1,46,733, ₹ 1,32,867 and ₹ 1,14,959 respectively which was again high in the 6th year. Financial analysis brought out that the agro-forestry system-I is more profitable, if the

Table 9: Financial viability of poplar cultivation under AFS-I and AFS-II

Year	AFS-I						AFS-II					
	BCR (Per cent)			NPV (Rs./Acre)			BCR (Per cent)			NPV (₹/Acre)		
	10%	12%	15%	10%	12%	15%	10%	12%	15%	10%	12%	15%
4	2.76	2.71	2.63	141050	131764	119249	2.39	2.35	2.28	154553	144830	131708
5	2.78	2.71	2.60	146286	134545	119054	2.41	2.34	2.26	159329	147191	131145
6	2.75	2.65	2.51	146733	132867	114959	2.39	2.31	2.20	159568	145326	126891

harvesting of poplar is done at the age of 5th year and the cost of capital is less than or equal to 12 per cent. If the cost of capital increased to 15 per cent the poplar should be harvested at the age of 4th year indicating the returns with the increase in age of poplars are less than the increase in cost of capital, which showed that poplar based agro-forestry was economically viable in the sampled area. Similar trends were reported by Singh (1999).

In case of agro-forestry system-II, the benefit-cost ratio in the 4th year at given rates of discount was 2.39, 2.35 and 2.28 respectively. The net present value on overall basis at 10, 12 and 15 per cent rate of discount was estimated at ₹ 1,59,553, ₹ 1,47,830 and ₹ 1,31,708 per acre respectively. Therefore, the comparative picture revealed that the benefit-cost ratio and net present value were more in 4th year of harvesting age as compared to 5th and 6th year respectively. The benefit-cost ratio and net present value is again highest at the 5th year age of harvesting at 12 per cent discount rate in AFS-II. If the discount rate increased to 15 per cent then it is beneficial to harvest the poplar at the age of 4th year. Though the undiscounted returns increased with the increase in the age of poplar but using discounting criteria it is indicated that the returns are highest at the age of 4th year if cost of capital is 15 per cent and above.

CONCLUSIONS

Poplar in India is now being raised on an increasing scale as an agro-forestry crop by the farmers on their field primarily for enhanced economics. Trees shed leaves during November to January and bear new leaves in March-April, which facilitates the intercropping with a wide range of crops. It is concluded from above analyze that the AFS-I is more profitable for all the categories of farmers, if the harvesting of poplar is done at the age of 5th year and the cost of capital is 12 per cent. In case

of AFS-II the benefit-cost ratio and net present value was highest at the 5th year age of harvesting at 12 per cent discount rate. If the discount rate increased to 15 per cent then it is beneficial to harvest the poplar at the age of 4th year. Though the undiscounted returns increased with the increase in the age of poplar but using discounting criteria it is indicated that the returns are highest at the age of 4th year if cost of capital is 15 per cent and above. The annuity values worked out at ₹ 43,386, ₹ 37,322 and ₹ 32,319 for AFS-I and ₹ 47,688, ₹ 40,829 and ₹ 35,350 for AFS-II in the 4th, 5th and 6th year of harvesting age. The net returns from wheat-paddy cultivation were estimated at ₹ 40,744 per annum. Thus, the annual returns from poplar in both the systems i.e. AFS-I and AFS-II were found to be higher than the wheat and paddy crop rotation. Thus, the poplar plantation was more beneficial than wheat and paddy crop rotation during the study year at the estimated costs and price of poplar as well as intercrops.

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